The -SiH functional group spectral feature in lunar soils. *E. Pierazzo, T. D. Swindle, R. B. Singer*. Lunar and Planetary Lab.; *R. P. Sperline*. Dept. of Chemistry. The University of Arizona, Tucson, AZ 85721

The surface of the moon is continuously exposed to solar wind ions impacting at velocities varying between 300 and 700 km/sec. Silicate minerals on the lunar surface therefore undergo ion-sputtering and ion-implantation at relatively low energies (1-5 keV for H^+ ions, 4-20 keV for He^{++} ions). As a result, very volatile elements such as H, He, C, N, and noble gases, that are extremely depleted on the Moon, are found in grains of lunar soils which have been directly exposed to the solar wind [1]. Nuth et al. [2] suggested that solar wind implantation of hydrogen on the lunar surface could lead to a measurable spectral infrared feature between 4.4 and 4.7 µm in both laboratory and telescopic spectra of lunar regolith due to -SiH functional groups. If true, this could lead to an innovative and powerful tool for remote sensing studies of the moon and asteroids for determining volatile implantation and regolith maturity. To test the hypothesis of Nuth et al. we measured the infrared spectrum of six lunar soils, without finding any evidence of a feature in the region of interest. This negative result is however in agreement with the work of Moore et al. [3] that showed a decay of the -SiH-related feature in time once the sample's irradiation stops, and does not exclude the possibility of finding the feature in telescopic spectra of lunar regolith.

The distribution of solar wind implanted elements on the lunar surface, the relationship of such distributions with soil maturity, and the possibility of utilization of solar wind implanted elements like hydrogen and helium as in-situ resources are challenging and scientifically important open questions. There is no technique currently proven for remote determination of implanted volatiles on planetary surfaces, and the only way to estimate the maturity of the lunar surface from remote observations is provided by a technique based on the depth of the crystalline mineral Fe^{2+} absorption (e.g. [4]). A way of remotely measuring solar wind exposure history for lunar soils using the -SiH fundamental stretch around 4.5 µm would be a major improvement.

Moore et al. [3] measured the infrared spectra of amorphous silicate grains and films formed in a veriety of laboratory experiments (including proton bombardment of Si-containing residues) and found that the wavelength of the -SiH fundamental stretch is extremely sensitive to the chemical environment of the grain in which the silicon is bound, varying from 4.4 µm in oxidized grains to about 4.74 µm in a reducing environment. They also proposed, following [5], that a feature previously observed in W33A (a bright compact infrared source considered to be a protostar) at 4.6 µm, and several small and as yet unidentified features in the 4.4-4.6 µm region observed in the Comet Halley spectra (obtained by the IKS-Vega instrument during its flyby trhough the coma of the comet) [6] could be attributed to -SiH groups bound either into or on the surfaces of amorphous silicate grains. Unfortunately no infrared reflection spectra are available in the literature for fresh lunar soils or rocks in the 4-5 µm region, nor are we aware of any telescopic measurement of the lunar surface in that wavelength region.

To test the presence of the -SiH functional group feature we measured the infrared spectrum (Fig. 1*a*) of six lunar soils from the NASA/JSC collection (see Table). The samples we analyzed are of various levels of maturity: three of them are classified as mature (10084, 15101, 66041), two as submature (71501, 75081), and one as immature (74241) (see table for more information). The samples were carefully mailed and handled in an N_2 atmosphere, to avoid contamination with air or water vapor. Infrared absorbance spectra of the samples, diluted in a KBr matrix, were measured on a Perkin-Elmer Fourier Transform InfraRed Spectrometer (FTIR) at the Strategic Metal Recovery Facility of the Department of Chemistry, University of Arizona, Tucson. The resulting spectra, Fig. 1b, show no evidence of the feature of interest. This negative result is, however, neither surprising nor discouraging. The -SiH functional group in silicate grains is not stable. The work of Moore et al. show that a decay of the feature due to the -SiH functional groups occurs on a timescale of months (at temperatures above 300 K) even if the samples are stored in vacuum. Therefore the feature is expected to decay in time with a half-life as low as a few months. The lack of the feature in the laboratory spectra of lunar soils can then be attributed to the fact that the the lunar samples have been removed from the lunar (irradiating) environment and stored for a period longer than the half-life of the feature in question.

As a next step it would be interesting to see if the spectral feature of the -SiH functional group can be seen in telescopic spectra of the moon. Even though the CO_2 and H_2O absorption in the Earth's atmosphere makes observations in the 4-5 μm range hard to do from the Earth's surface, we believe it could still be done because the wavelength region of interest for a reduced regolith like the moon falls in a small window between two strong absorption bands.

REFERENCES: [1] Heiken G. H. et al. (1991), *Lunar Sourcebook*, Cambridge Univ. Press; [2] Nuth J. A. et al. (1992), Icarus 98, p. 207; [3] Moore M. et al. (1991), Astrophys. J. 373, p. L31; [4] Lucey et al. (1995), Science 268, p. 1149; [5] Nuth J. A. and M. H. Moore (1988), Astrophys. J. 329, p. L113; [6] Combes M. et al. (1987) A. and A. 187, p. 513.

Sample	Mission	Is/FeO	% TiO_2	Type
10084	Apollo 11 ('69)	78	7.56	Mare Basalt
15101	Apollo 15 ('71)	70		Complex
66041	Apollo 17 ('72)	90	0.63	Highlands
71501	Apollo 17 ('72)	35		Highland/Mare boundary
74241	Apollo 17 ('72)	5.1	8.61	Highland/Mare boundary
75081	Apollo 17 ('72)	40	9.52	Highland/Mar boundary

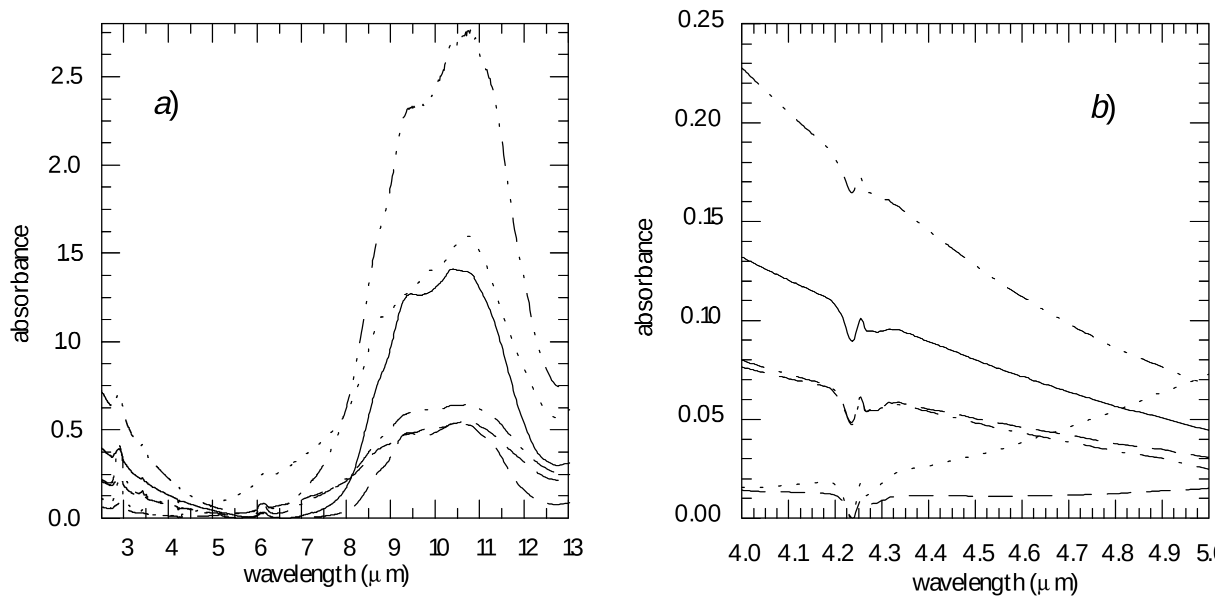

Figure 1: a) InfraRed spectrum of six lunar soils: 10084 (solid), 15101 (dash), 66041 (dot), 71501 (dot-dash), 74241 (double dot-dash), 75081 (short dash). The major feature in the 8-12 μm region is due to the Si-O vibrational stretching of silicate minerals. b) Details of the infrared spectrum in the region 4-5 μm, showing no evidence of a feature around 4.5-4.7 μm (the feature around 4.2 μm is related to the KBr matrix).